American? So far as I am aware these still remain to be discovered.

When, however, Mr. Boulenger asserts (*l. c.* p. 346) that "A list of the lizards of any northern district of the United States would equally well support my [Boulenger's] view," I can but say that this statement so far traverses beyond the facts that it can only be met with a most emphatic denial. In the whole of the United States east of a north and south line connecting the mouth of the Rio Grande with Canada, or over an area of approximately 1,500,000 square miles, there is scarcely a single lizard which has any Neotropical affinities whatever, and still less so in any northern section of this area.

In the fact that some four or five species of lizards, of a somewhat southern type (*Sceloporus*, *Phrynosoma*), range as far north as British Columbia there is about as much reason for uniting the North- and South-American Lacertilian faunas as there is for uniting the equivalent bird-faunas because along the same limited tract several species of humming-birds range deep into Canada (and Alaska!), or because a parrot and the scarlet tanager (&c.) are found in the eastern and southern United States. Similarly we might unite the northern and southern mammalian faunas on the equally obvious ground that the couguar, skunk, and bear range deep into South America, and, conversely, the peccary, opossum, &c. far into North America.

VI.—*Contributions to the Knowledge of the Reproduction of* Euglypha alveolata, *Duj.* By Dr. F. Blochmann *.

[Plate IV.]

In the glasses with mud from the two basins in the garden of the Schwetzinger Schloss, in which I formerly detected *Hæmatococcus Bütschlii*, the *Euglyphæ*, which were at first not very numerous, increased considerably. This induced me to seek for divisional stages, which also occurred in abundance. Mr. Schewiakoff undertook to submit the more delicate processes in the division, especially that of the nucleus, to a thorough investigation, and his memoir upon this subject will appear shortly. For my own part I made an observa-

* Translated by W. S. Dallas, F.L.S., from the 'Morphologisches Jahrbuch,' Band xiii. pp. 173–183 (1887).

tion upon this occasion which, when followed out, led to results which were of some interest, and these I describe in the following pages. They may in some respects serve as a supplement to Gruber's beautiful investigations *, by which the process of division in the shell-bearing freshwater Rhizopods was first thoroughly elucidated.

As is well known, the process of division runs as follows :— In an animal which has already formed the necessary shell-lamellæ in its interior the protoplasm is protruded from the orifice in the form of a small bud covered with shell-lamellæ. This flowing forth of the plasma continues until the mass outside the original shell, now covered with the new shell-lamellæ, has attained the same volume and the same shape as the original animal. During this process the nucleus also divides and one half of it passes into the newly produced individual, so that in this way *two* perfectly similar animals are produced, and these soon separate from each other to live as individual animals.

However, the separation of the animals thus produced does not always occur; but by no means unfrequently we may observe a very remarkable process, by which, while it is true that two shells and two nuclei are produced, only a single animal proceeds from such a division.

Thus after the division has taken place quite normally and the nucleus of the newly formed individual has occupied its ordinary position at the bottom of the new shell, the protoplasm is retracted out of the newly formed shell (Pl. IV. fig. 1), still, however, remaining attached to the bottom of the shell, so that from this point a comparatively thin cord stretches towards the aperture along the axis of the shell, passing about in the middle of the shell into a larger mass of plasma. The greater part of this cord appears quite hyaline, containing only extremely fine granules; this is caused by the position here of the nucleus (n^2), which has now become nearly cylindrical.

In the principal mass of the plasma, especially between the two orifices now pressed close together, active flow-phenomena are observable, just such as were also observed by Gruber during division. Upon continuing the observation it is seen that the cord in the new shell is drawn out into a thin thread, while the nucleus again acquires its regularly spherical form (fig. 2).

This thread is now seen to become alternately thicker and

* "Der Theilungsvorgang bei *Euglypha alveolata*," in Zeitschr. für wiss. Zool. Bd. xxxv. pp. 431–439 (1881). See 'Annals,' ser. 5, vol. ix. p. 135.

thinner, by the flux and reflux of plasma from the large plasma-mass. All at once, however, the thread becomes thinner and thinner, until it is suddenly ruptured. At the same moment a distinct reticulated structure (fig. 3) makes its appearance suddenly and sharply in the nucleus (n^2), which was previously perfectly limpid, like the nuclei of *Euglypha* in general, a structure such as we can call forth in the normal nucleus by the addition of acetic acid or any other reagent causing coagulation. From this, as also from the further behaviour of this nucleus, which will be immediately described, it follows with great certainty that at the moment when the plasma-thread is ruptured it also dies. This fact is of particular interest on account of the close relation of the nucleus to the plasma which is proved by it. The nucleus therefore is not capable of retaining its normal vital condition even for a moment when isolated from the plasma.

The nucleus thus thrown off remains enclosed in a thin layer of plasma, as shown in the figures; this appears to be only the peculiar plasma-zone which may be detected even in normal individuals in the neighbourhood of the nucleus, and which also behaves towards colouring-matters differently from the rest of the plasma.

After the cell-nucleus of the newly formed individual has been thrown off in this way two cases may occur. In the first case the plasma withdraws itself completely from shell II., and the normal animal separates from it. In water which contains numerous* *Euglyphæ* in process of division there are therefore always empty shells which show at the bottom the expelled cell-nucleus as a yellowish strongly refractive corpuscle.

The second case, which probably occurs just as frequently, is represented in figs. 5–9. In this, after the plasma has been retracted almost entirely into the old shell, it suddenly begins again to flow over towards II., during which process one (fig. 5) or more thickish or very fine pseudopodia are formed, which move about, as if groping, through the cavity of shell II. As soon as they meet with the expelled cell-nucleus they flow round it, just like any foreign body serving for food. It becomes detached from the bottom of the shell where it was seated, and is carried away with the plasma, now again flowing back towards I. (figs. 6–8). We see that it is finally drawn into shell I. Here it may now remain

* In our waters the animals were so numerous that every drop taken from the bottom of the vessel and put upon a slide showed twenty or thirty specimens.

until the shells have separated, and then be again finally expelled, or this expulsion may take place before the separation of the shells (fig. 9). During its sojourn in the plasma of the intact animal the nucleus n^2 changes its constitution. At first it still distinctly shows the reticulated structure which appeared in it at the time of the rupture of the plasma-thread uniting it with the body of the animal. Gradually this structure disappears, and the nucleus acquires a more homogeneous strongly shining appearance, while its outlines become irregular (figs. 8 and 9). It therefore has exactly the aspect which is presented by other nuclei which have perished. Therefore it is like the nuclei undergoing degeneration during the conjugation of Infusoria, or like the nuclei of Protozoa which have been devoured by other Protozoa and partially digested. As already stated, the nucleus is finally again expelled. Then, however, the plasmatic envelope which it originally possessed seems to be lost. It has therefore no doubt been digested, while the nuclear substance itself appears not to be assimilable.

In this process therefore there results from a division which, so far as one can judge, was normally commenced and carried on, only a single individual, the plasma becoming retracted again from the new-formed shell into the old one, while one of the nuclei is thrown off.

If we meet with a pair of animals, such as is represented in fig. 1, and observe in it the processes described, of course it seems a very probable notion that the two animals have united by copulation. Now actual copulation and conjugation * do really occur, as I shall show further on. It is, however, easy to distinguish a conjugation-pair from one produced by division. In the animals united by conjugation there is very generally a mass of shell-lamellæ in the plasma, while this is not the case in the products of division, as it is exactly the superfluous shell-plates of the parent animal that are employed in the formation of the new shell. Further, in stained preparations the young shell (II. in the figures) is usually recognized with facility, because the individual plates have separated from each other at different places. In conjugated animals I have always found, placed before the nucleus,

* As will be shown hereafter, both copulation (in which the plasma-bodies of two animals become completely fused together to form a new individual) and conjugation (in which the animals, after long-continued union, separate again from each other, and in which hitherto no demonstrable changes have been observed) do occur. For the sake of simplicity I speak here always of conjugation-pairs, as they certainly constitute the great majority of the united states which come under observation.

the dark zone formed by aggregation of granules, which is wanting in freshly divided animals. In the latter the granules are uniformly distributed throughout the plasma, and for this reason and on account of the inception of water requisite during division, the plasma of divided individuals appears much lighter, so that with a little practice one may distinguish a divisional pair from a conjugation-pair even with the lens.

The consideration of all these differences would not, however, completely exclude mistakes. To attain this object I isolated animals in which the plasma was just beginning to protrude from the aperture as small buds covered with shell-plates, and which therefore were certainly at the beginning of division. As the division advanced, the division of the nucleus might also be observed with facility in living animals. By this mode of investigation all mistakes are excluded. In this way I isolated and observed a great number of *Euglyphæ*, and it appeared that after the conclusion of the division either the two individuals separated and continued to live independently, as was already observed by Gruber (*loc. cit.*), or that the process above described took place, so that only *one* individual resulted, which, indeed, contained nearly the whole of the plasma of the parent animal, but only half its nuclear substance.

I have investigated the most different stages of both processes of division and of nucleus-expulsion in preparations killed with chrom-osmium-acetic acid and stained in different ways, without, however, observing in them anything essential more than in fresh objects or objects treated with 1 per cent. acetic acid.

If we ask ourselves what significance this remarkable process has for the animal, it is at present very difficult to find any answer that may be satisfactory even to a limited extent. In the individuals thus produced I have observed nothing remarkable; they lived for a time in the preparations like others, then perished or became encysted.

At the first glance one might imagine a comparison of this process of nucleus-expulsion with the removal of the products of division of the nucleoles in the conjugation of the Infusoria. In connexion with this Prof. Bütschli has suggested that possibly such animals as had lost in this way the half of their original nuclear substance afterwards proceeded to copulation. Hitherto, however, we have no positive observations in favour of this view. But in the most recent observations of Maupas* upon the conjugation of the Infusoria we may find some sup-

* 'Comptes Rendus,' June 28 and September 6, 1886.

port for such a supposition. According to them a number of the divisional products of each nucleolus would perish, as indeed was previously known, whilst of the two nucleolar derivatives remaining in each of the conjugated animals one would pass over into the other animal and become amalgamated with that remaining in it. By this, as Maupas points out, the conjugation of the Infusoria is brought into closer relation to the process of fecundation in the Metazoa than was previously possible.

According to this line of thought we might find a certain relation between the process described in *Euglypha* and the formation of the direction-corpuscles in the ova of the Metazoa. In both cases the final result is the removal of a part of the nuclear substance. In both cases this is effected by an indirect division of the nucleus connected with a cell-division. But whether these suppositions have any real foundation must be left to further extended investigations to show.

Similar processes to those here described in the case of *Euglypha* have not hitherto, so far as I know, been noticed in any other Rhizopod. I think, however, that careful investigation will show a wider diffusion of these processes. Thus I feel certain that the supposed copulation-stage of *Difflugia globulosa*, Duj., described by Jickeli *, was a similar case of retrogressive division with expulsion of the nucleus. He states expressly that one of the two shells (*i. e.* the newly produced one) was clearer, and that in forty-eight hours the whole of the plasma, originally filling both shells, had passed over into the darker (*i. e.* the original) one, in which careful examination showed two normal nuclei and one in course of disintegration.

All this agrees with the processes observed by me in *Euglypha*. We should therefore have to understand that Jickeli discovered a completely finished division of the *Difflugia*, that this then retrograded, the plasma withdrawing itself from the newly formed shell, leaving behind it the nucleus, and that it then subsequently again took up the dead nucleus. After this had taken place the animal was killed; but the decaying nucleus would certainly afterwards have been again expelled.

In another case, in the formation of the resting-cysts of *Actinosphærium Eichhornii*, Ehrb. †, it has been directly

* "Ueber die Copulation von *Difflugia globulosa*, Duj.," in Zool. Anz. Jahrg. vii. pp. 449–451 (1884). Translated in 'Annals,' ser. 5, vol. xiv. p. 297.

† On the literature see Bütschli, 'Protozoa.'

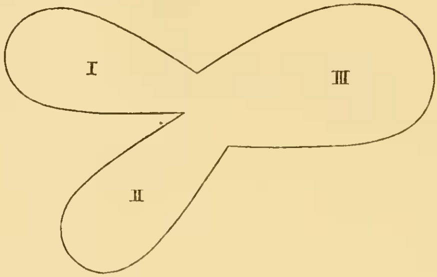
observed that two individuals just produced by division become again completely fused together. Nothing indeed is said of an expulsion of the nucleus; but to establish the matter with certainty an investigation specially directed to that end would be necessary. In general, however, this process has a very great resemblance to what occurs in *Euglypha*.

I have also observed true copulation in *Euglypha*, but unfortunately only in one instance, and not so thoroughly as I could have wished.

When many *Euglyphæ* are living together one often meets with several animals which have placed themselves with their shell-apertures together, and of which the plasma has become amalgamated. As has already been stated, such conjugation-pairs may be distinguished with certainty from the pairs produced by division. But in order to be absolutely certain in these investigations I always got a small number (six to ten individual animals) into the suspended drop, and observed them here. Any conjugation-pairs that might be present were taken out and isolated in another drop for further observation. In this way it appeared that in most cases the conjugation is again dissolved, without any noticeable change having taken place in the animals. To see whether any changes were perceptible in the nucleus I examined many stained preparations of animals united in pairs or several together, but always without result.

The separated animals also behaved differently; some of them divided normally, while others became encysted like ordinary individuals.

Once, however, I observed the following:—In a preparation with a number of individual animals there were two united pairs at a quarter to six in the evening of the 26th May of last year (1886). Both pairs were isolated in suspended drops. On May 27 no alteration was observed; so also at seven in the morning of May 28. But about seven in the evening I found the condition shown in the accompanying woodcut. While one pair was still unaltered, the plasma of the two other individuals (I. and II.) had united, and had formed from the shell-lamellæ previously in the interior of the two animals a new large shell (III.) of somewhat irregular shape, at the aperture of which the two original shells, completely empty, were attached. The length of this newly formed shell was 100 μ and its greatest breadth 67 μ, while the average of twenty shells taken at random from different culture-vessels amounted to 82 μ for the length and 47 μ for the greatest breadth. From this it appears that the newly formed shell of the individual produced by copulation exceeded the normal measurement by about 20 μ in each dimension.



× 300.

In the large animal III. a nucleus was visible in the usual position. As to the behaviour of the two nuclei of the copulating animals I. and II., I could make no observations owing to the nature of the case. The most natural supposition seems to me to be that the two nuclei were fused together. The large individual crept about briskly in the drop for several days and was finally encysted on June 2. The two other conjugated animals in the same preparation separated again from each other, and one of them divided in the normal manner.

In this instance, therefore, there can be no doubt that actual copulation occurs in *Euglypha*, only it seems to be comparatively rare; and hence its exact observation must depend upon favourable circumstances, which, considering the importance of the matter, is much to be regretted.

When through recent investigations, and especially by Gruber's memoirs, the process of division in the freshwater Monothalamia was elucidated in all essential particulars, it appeared only too natural that there should be a great tendency to assume, as indeed had even previously been done by Hertwig and Lesser *, that all statements as to the copulation and conjugation of the shelled freshwater Rhizopods were founded upon such divisional stages misunderstood. In many cases this might probably apply, in some perhaps not. Of course from the figures and descriptions it will be difficult or even impossible in special cases to decide in favour of one or

* "Ueber Rhizopoden und denselben nahestehenden Organismen," in Arch. für mikr. Anat. Bd. x. Suppl. pp. 35–243 (1879).

the other view. In fact there is not much use in testing the extant instances for this purpose, as usually some special mode of increase connected with the conjugation was observed, although not with certainty. In one instance, however, such a special kind of multiplication after an undoubted conjugation seemed to be very probable, namely in *Arcella vulgaris*, Ehrbg., according to Bütschli's observations *. In this it was observed that in two out of three conjugated *Arcellæ* amœboid offshoots were produced in great numbers after the dissolution of the conjugation †.

In my subject I have hitherto observed nothing of the kind, although I examined numerous animals united in pairs and several together, both living and in stained preparations.

The proof here adduced of true copulation in *Euglypha*, in which from two normal individuals a single animal agreeing with them in structure but exceeding them in size is produced, is, however, of importance. I rejoice that in this way I have made the first step towards the confirmation of the supposition expressed by Bütschli in his work on the Protozoa, that, as in the other Protozoa, so also in the Rhizopoda, the processes of copulation and conjugation might have assigned to them an important part in reproduction.

In the case of shelled Rhizopods, so far as I know, an actual copulation has never previously been demonstrated, although it is sufficiently well known in the nearly allied Heliozoa.

Finally, it may further be indicated that in the process of copulation in *Euglypha alveolata* we cannot overlook a certain resemblance to the formation of axospores in the Diatomaceæ.

Although, as is to be expected, future investigations will demonstrate the wider diffusion of conjugation and copulation in the Rhizopoda, we may nevertheless already say with considerable certainty that they will never occur with the same regularity as in many Flagellata and Infusoria, but that they will always be rather occasional phenomena, the importance of which, however, must not on that account be underestimated, as in any case they certainly are the first commencement of processes to which, in the life of animals in general, an extraordinarily great, although still by no means clear, significance belongs.

* Arch. für mikr. Anat. Bd. xi. pp. 459-467 (1874).

† I have convinced myself of the occurrence of conjugation in *Arcella*. In a vessel which contained enormous quantities of *Arcellæ* I found by no means unfrequently two animals with perfectly similar deep brown shells united, while the pairs produced by division, which were present in abundance, were readily recognized by the nearly colourless shell of one offshoot.

EXPLANATION OF PLATE IV.

All the figures, with the exception of fig. 4, are from the living subject. Fig. 4 is from a preparation treated with 1 per-cent. acetic acid. Enlargement 400 diameters.

I. First individual (parent animal).
II. Second individual, produced by division from I.
n^1, nucleus of the first animal.
n^2, nucleus of the second animal.
CV, contractile vacuole.

Fig. 1. The plasma begins to withdraw itself from the animal II., produced by division from I. At the bottom of the shell it is still firmly attached and encloses the nucleus n^2, which is somewhat elongated.
Fig. 2. The process is further advanced, and the plasma is drawn out into a thin thread. The nucleus n^2 has again assumed its normal form.
Fig. 3. The thread is ruptured and the nucleus n^2 shows distinct reticular structure; it is dead.
Fig. 4. The expelled nucleus n^2 of another animal, after treatment with acetic acid of 1 per cent.
Fig. 5. The plasma is flowing again into shell II., and emits a pseudopodium towards the nucleus n^2.
Fig. 6. The pseudopodium has flowed round the nucleus n^2, and is drawing it back towards shell I.
Fig. 7. This process has further advanced.
Fig. 8. The nucleus n^2 has lost its structure, and appears as a strongly refractive irregular mass.
Fig. 9. The nucleus n^2 is again expelled.

VII.—*Notes on the Determination of the Fossil Teeth of* Myliobatis, *with a Revision of the English Eocene Species.* By A. Smith Woodward, F.G.S., F.Z.S., of the British Museum (Natural History).

[Plate I.]

Of all the numerous teeth of Selachian fishes met with in a fossil state none seem to have been studied with less satisfactory results than those of the well-known genus *Myliobatis*. Abundantly represented in nearly all the marine Tertiary formations, detached fragments of its dentition have been described under almost endless specific names from various parts of the world; and the most precise measurements have often been given, without the slightest reference to differences of age or even to variations in the individual jaw. Occasion-